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TRANSISTOR DRIVE CIRCUITS FOR DEKATRONS

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ABSTRACT. Transistor drive circuits have been described for GC10/4B dekatrons by Chaplin and Kandiah (1958). These apply paired pulses of 80 μ sec duration and 80 volts amplitude to the dekatron guides and claim a resolving time of 300 microseconds.

A transistor circuit suitable for the faster GC 10D dekatron that attains a resolving time of 40 μ sec has been described by the authors. This supplies a 20 μ sec, 150 volt pulse and is essentially a blocking oscillator pulser using a ferrite core transformer The transformer design details have also been described. The circuit is simple and reliable and works over a supply voltage range of 7.5 volts to 18 volts. The current drain at pulse rate of 5000 is only 2.0 mA at 12 volts. This is strikingly low when one remembers that the current drain for a paired pulse drive circuit is 10 mA at a pulse rate of 500 only.

Following this, a similar circuit for GC 10B, that needs 60 μ sec pulses was developed. At 5000 pulse rate its current drain is 12 mA at 12 volts supply. This circuit also works over a range of 7.5 volts to 18 volts. It is essentially more simple and reliable compared to the paired pulse drive circuits and shows a resolving time (200 μ sec) that is better than the manufacturers figure for this dekatron.

INTRODUCTION

Of all devices used for decade counting, the glow transfer type dekatrons appear to be the most simple. Extremely low operating power (0.15 watts) and reliability are its further attractions. Combined with a transistor drive circuit and transistorized high tension and extra high tension, perhaps the last word is reached in the development of a portable nuclear counting system that is simple and reliable, efficient and elegant.

Transistor drive circuits have been described by Chaplin and Kandiah (1958). These are for use with the neon-filled GC 10/4B dekatrons that have 250 μ sec resolving time. Paired pulses of 80 μ sec duration and 80 volts amplitude with adequate overlap, are applied by these circuits to the two guide electrodes of these dekratons. Resolving time of 300 μ sec has been claimed for these circuits, which use five crystal diodes, five resistors, two capacitors and a special transformer using a ferrite core. These circuits are adequate for nuclear counting system using G.M Counters that have dead times in the range of 100 microseconds.

The scintillation detector, which gives a very great improvement in detection efficiency for γ-rays, is however capable of much faster counting. Scintillation γ-ray spectrometers commonly utilize a pulse width of one microsecond. Very high counting rates (a million per minute) are often encountered. Counting systems must therefore have resolving times of one to five microseconds.

Such short resolving times are offered by transistor binary scaling circuits (Chaplin, 1956). We have found them equally reliable but the power consumption, components and cost per scale of two, exceed that for the drive circuit of a dekatron.

An argon filled dekatron is also available that has a resolving time of 50 μ sec. It is the three guide single pulse GC 10D that requires a 145 volt, 25 μ sec driving pulse. A transistor drive circuit for this tube is a more difficult design problem, chiefly because of the bigger pulse amplitude required with the shorter duration. Besides, since the preceding binaries will smooth out the randomness in the arrival of pulses to it, average counting rates to which this circuit may be subjected may run to 10,000 counts/sec. With such a high rate, power dissipation* in the driving transistor might be a cause for worry. Collector dissipation in common transistor types like OC 72 must not exceed 40 milliwatts for reliable operation in this country.

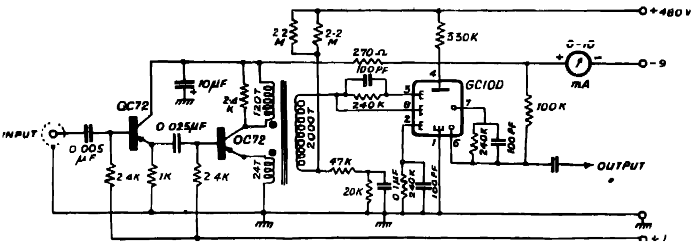


Fig. 1. GC 10D drive circuit

However, we have found such a circuit (Fig. 1) feasible. The most important component is evidently the ferrite core transformer. It utilizes interleaved windings as shown in Fig. 2. The insulation between windings is silicone tape and it was impregnated with Z 920 silicone varnish. Ferroxcube pot cores§ with the minimum unavoidable air gap, helps to keep down collector overshoot. The core does not saturate in the 20 μ sec pulse duration which is controlled by choosing the value of C (0.03 mfd) suitably. The circuit works over a supply voltage range of 7.5** volts to 18 volts If the base bias is reduced, the circuit would work up to even 4.5 volts, but the repetition rate must not exceed 500 per

*The average current in one of our units for GC 10 B, using a paired pulse drive circuit of Kandiah type, exceeds 10 mA with a repetition rate of only 500 per second.

§Philips D-36/22-10 00 III B1

**It is surprising to find that the GC 10 D operates reliably over a pulse amplitude range of 100 to 250 volts, in this circuit, whereas the manufacturer recommends only 144^{+50}_{-12} volts drive pulses. This has been verified in respect of all the twenty tubes we had in stock.

second, and the trigger pulse width must be more than 5 μ sec. This limitation in the repetition rate is probably due to the increase in the average $d-c$ level of the drive pulses at higher pulse rate so that higher amplitude drive pulses will be needed for a glow transfer. Also for a constant value of C, reduction in the supply voltage necessitates a longer duration trigger pulse for maintaining regeneration in the circuit. The current drain at 12 volts is only 2 mA with a pulse rate of 5000 per second. The trigger pulse need have a width of 2 microseconds and a little over 1.5 volts* in amplitude. Such a pulse is readily obtained from the preceding transistor binary.

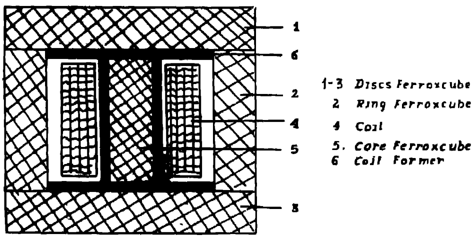


Fig 2(a). Design of the blocking oscillator transformer.

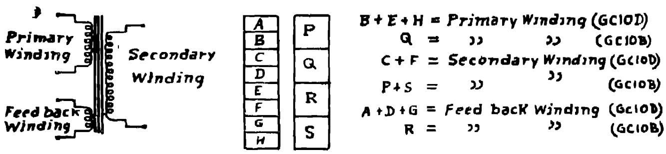


Fig. 2(b). Details of the coil winding of transformer in the GC10D and GC 10B circuits.

The resolving time (and other performance data reported here) was measured in the arrangement of Fig. 3 and was found better than 50 microseconds. The

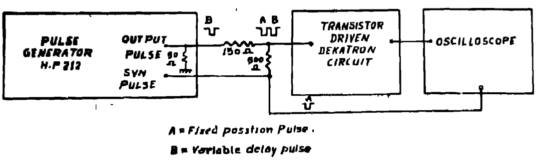
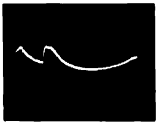


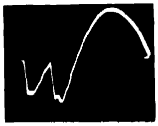
Fig. 3. Arrangement for the measurement of the resolving time of the circuits.

*The amplitude of the trigger pulse should be a little greater than the base bias. Smaller bias makes the circuit more sensitive.

oscillograms may be seen in Fig. 4a The large overshoot that follows each drive pulse in it (and also in Fig. 4b) rules out the possibility of glow resting on any of the transfer electrodes. Furthermore, an appreciable overlap is automatically maintained in these circuits (Fig. 1 and Fig. 5). Overlap ensures smooth transfer of the glow from the cathode to the first, second and third guides successively and adds to the inherent reliability of the operation of the tubes.

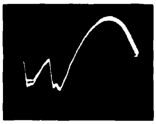
Waveform at the collector



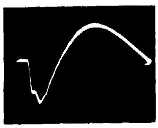


Waveform at the guide No. 1.

Waveform at the guide No. 2.



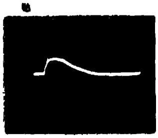
Waveform at the guide No. 3.

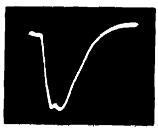


Output of the transistor drive circuit for GC 10D

Fig. 4(a). Oscillograms showing the response of the transistor drive circuit for GC 10D, to two input pulses separated by an interval of about 50μ sec.

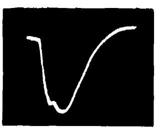
Waveform at the collector

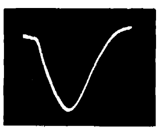




Output of the transistor drive circuit for GC 10B.

Waveform at guide No. 1.





Waveform at guide No. 2.

Fig. 4(b). Oscillograms showing the response of the transistor drive circuit for GC 10B.

The surprisingly low current drain of this circuit prompted an enquiry if a circuit for GC 10 B could be developed on these lines which would have much lower current drain. It was felt that the larger current drain of the paired pulse drive circuits (Chaplin, Kandiah) was due to two causes. First, one has to supply the power for storing adequate energy in the magnetic fields of the core, so that a large overshoot, necessary for generation of the second pulse, is produced. Secondly, one has to supply the power dissipated in the back resistance of the crystal diodes that switch the pulses on the dekatron guide electrodes. It was felt that an integrated pulse drive circuit (Ericsson Handbook) instead of the paired pulse, would have greatly reduced current drain The circuit, as finally developed, is shown in Fig. 5 The resolving time has not been sacrificed in the least, in as much as the circuit counts correctly up to 5000 pulses per second, whereas the manufacturers specification is only 4000 pulses per second. The current drain at 5000 pulse rate is only 12mA at 12 volts which represents tremendous improvement.

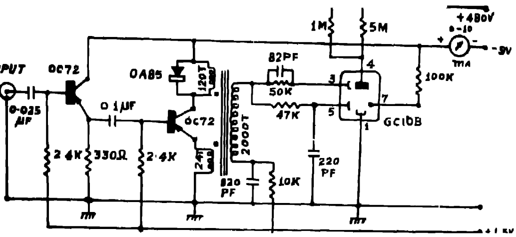


Fig. 5. GC 10B drive circuit.

The circuit works reliably over a supply voltage range of 7.5 volts to 18 volts and it will be seen (Fig. 5) that it is simpler than the paired pulse circuit In the paired pulse circuits of Chaplin and Kandiah, high back voltages to which the switching diodes across dekatron guides are subjected, introduce a likely cause of failure. Reliability is further endangered in these circuits as the transistor is also subjected to the extremes of its ratings

The design of the ferrite core transformer, the most important component of these transistor circuits, is actually simpler than the paired pulse circuits, and is given in Fig. 2. A pulse width of 60 microseconds is needed by GC 10B and this is adjusted again by choosing a suitable value for C. The oscillograms may be seen in Fig. 4b. The crystal diode across transformer primary (Fig. 5) not only clips overshoot, but also conserves current drain, as it returns a good part of the magnetic energy back into the supply.

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